(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 461 721 A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 91201429.7

(22) Date of filing: 11.06.91

(51) Int. Cl.5: H04B 14/06, H04L 27/06, H04L 27/04, H04L 27/20

(30) Priority: 15.06.90 NL 9001360

(43) Date of publication of application: 18.12.91 Bulletin 91/51

(84) Designated Contracting States: DE FR GB IT SE

(71) Applicant: N.V. Philips' Gloeilampenfabrieken
Groenewoudseweg 1
NL-5621 BA Eindhoven(NL)

(72) Inventor: Voorman, Johannes Otto
c/o INT. OCTROOIBUREAU B.V., Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(74) Representative: De Jongh, Cornelis Dominicus et al
INTERNATIONAAL OCTROOIBUREAU B.V.
Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(54) **Transmitter comprising an electronic arrangement for generating a modulated carrier signal.**

(57) Transmitter comprising an electronic arrangement for generating a modulated carrier signal, this arrangement comprising at least an adder included in a closed signal loop, a low-pass filter and a pulse shaper driven with a specific sample rate and constituted by a sigma-delta (one-bit) signal converter which includes a mixer driven with the carrier frequency fc so that the output signal of the pulse shaper is applied to the mixer and the frequency fc is equal to that or an integer multiple of the half sample rate.

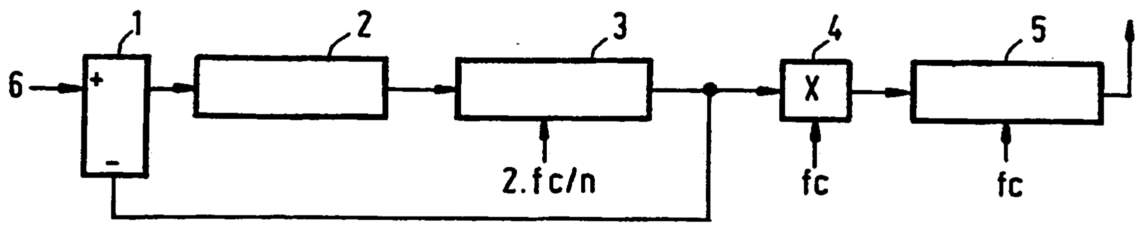

FIG.1

EP 0 461 721 A1

The invention relates to a transmitter comprising an electronic arrangement for generating a modulated carrier signal, this arrangement comprising at least an adder included in a closed signal loop, a low-pass filter and a pulse shaper driven with a specific sample rate and constituted by a sigma-delta (one-bit) signal converter.

An electronic arrangement of this type is generally known as a one-bit coder. When a signal having frequencies f of the band around f=0 is applied to the input of the adder of the prior-art arrangement (baseband signal), and the pulse-shaper is driven with frequency fs, the coder output signal comprises, in addition to the baseband signal around f=0, the carrier amplitude modulated baseband signal with frequencies fc = n.fs (n = ...-2,-1,+1,+2,...). The frequency spectrum between the amplitude modulated carriers is filled with so-called quantization noise. With the aid of a band-pass filter a desired amplitude modulated carrier having frequency fc can be filtered out and thus, in principle one has the disposal of a one-bit transmitter.

In order to avoid signal leakage, the pulse shaper may be designed such that it generates a one-bit signal consisting of (mutually equal) positive and (mutually equal) negative pulses of a width of 1/(2.fs), separated by blanks (that is to say, intervals in which there is no signal) of the same width.

The prior-art arrangement has an inherent disadvantage. In a practical embodiment the pulses of the one-bit signal have a finite width. As a result, the amplitude-modulated carriers are weakened relative to the baseband signal. When an amplifier output stage for two-level or three-level signals (followed by a band-pass filter) is used, this will lead to a loss of efficiency in the amplifier output stage of the transmitter in which the arrangement is used.

It is an object of the invention to provide a one-bit transmitter which does not present this disadvantage. This object is achieved according to the invention with an arrangement for generating a modulated carrier signal, which arrangement comprises a mixer driven with carrier frequency fc, so that the output signal of the pulse shaper is applied to the mixer and the frequency fc is equal to that or an integer multiple of the half sample rate.

In a one-bit transmitter according to the invention the mixer produces a sum of frequency-shifted spectrums so that the amplitude modulated carrier around fc (and -fc) is unattenuated. The baseband signal and all further amplitude modulated signals are now attenuated indeed. With the same power dissipation of the output amplifier stage a larger signal is now fed to the antenna through the band-pass filter. In order to avoid quantization noise being modulated to a frequency band around the carrier frequency fc, according to the invention the carrier frequency fc is selected in such a way that it is equal to or an integer multiple of the half sample rate (fc = n.fs/2, where fs is the sample rate of the pulse shaper, and n = 1,2,3,...).

In a preferred embodiment of a transmitter according to the invention the mixer forms part of a closed signal loop and this loop comprises a second mixer driven with carrier frequency fc, so that the output signal of the first mixer is applied to the second mixer. In this preferred embodiment distortion and noise within the baseband are strongly suppressed in the first mixer as this mixer is included in the forward-directing part of the closed signal loop. The modulated signal is demodulated in the feedback part of the closed loop by the second mixer. If the pulses in the one-bit signal are separated by blanks, this signal can be processed in a three-level output stage, followed by a band-pass filter. If the pulses are not separated by blanks, it will be sufficient to use a simpler two-level output stage.

In an exemplary embodiment of an arrangement comprising a second mixer, the closed signal loop also includes a power amplifier. With a power amplifier included in the signal loop one has the disposal of a power amplifier wherein, as a result of signal feedback, the signal distortion is strongly reduced.

The requirement that the carrier frequency fc be equal to or an integer multiple of the half sample rate lays heavy demands on the free choice of the carrier frequency fc in the case where a digital input signal and/or a digital low-pass filter in the signal loop is concerned.

In another exemplary embodiment of an arrangement according to the invention, the arrangement comprises a digital-to-analog signal converter or a sample rate converter whose output is connected to an input of the adder. For example, a digital interpolator circuit driven with a certain frequency fs can be used as a sample rate converter. By means of the digital interpolator circuit a digital input signal can be converted into a one-bit signal. If an analog *in lieu* of a digital low-pass filter is used in the signal loop, it is possible to drive the interpolator circuit before the loop and the pulse shaper within the loop with different sample rates.

In a further exemplary embodiment a transmitter is obtained which comprises an electronic arrangement for generating an exponentially modulated carrier signal, which transmitter comprises at least two parallel combinations for modulating a carrier signal, or a signal shifted in phase by 90° relative to this carrier signal respectively, by means of an in-phase baseband signal or a quadrature baseband signal respectively. In this exemplary

embodiment the parallel combinations comprise each a preferred embodiment of an arrangement according to the invention wherein the closed signal loops of the two parallel combinations contain each two mixers and wherein the two mixers in one parallel combination are driven by means of a signal whose frequency fc is equal to the signal by which the two mixers in the other parallel combination are driven and is phase-shifted by 90° relative to that signal. For driving the mixers preferably three-level signals are used, for example, of the type in which the pulses are separated by blanks and have the same width as the pulses.

The output signals of the two parallel combinations are two modulated one-bit signals shifted in phase relative to each other by 90°. The pulses in these signals are separated by blanks. The blanks of one signal coincide with the pulses of the other signal and *vice versa* so that the signals can be combined to a single two-level signal. The latter signal can then be processed in prior-art manner in a power-efficient switched output amplifier.

With the latter exemplary embodiment one has the disposal in the frequency band around the carrier frequency of an exponential modulator that can be used transparently, for example, for amplitude modulation, vestigial sideband amplitude modulation, single sideband amplitude modulation, frequency modulation or phase modulation. The nature of the modulation is determined by the input signals on the parallel circuits, not by the circuits *per se*.

A transmitter comprising a two-level exponential modulator according to the invention presents important practical advantages over the prior art three-level exponential modulator disclosed in Dutch Patent Application No. 8101109, which application has the disadvantage that under specific circumstances, for example, in the case where signals occur having a small amplitude, the three-level signal may present very narrow peaks which the known circuit is unable to produce in an undistorted manner. This will thus lead to signal distortion. In addition, a two-level switched output stage can be constructed in a simpler manner than a three-level stage.

In an exemplary embodiment of a transmitter comprising a two-level exponential modulator according to the invention, this transmitter comprises two digital-to-analog signal converters (D/A) or two sample rate converters, the output of one or the other D/A signal converter or the sample rate converter respectively, being connected to an input of the adder in one or the other parallel combination. In an exponential modulator of this type digital input signals can be converted into analog signals or into one-bit signals by means of the sample rate converters.

The invention will be further explained hereinafter with the aid of exemplary embodiments and with reference to the drawing Figures in which:

Fig. 1 shows a block diagram of a simple exemplary embodiment for a one-bit transmitter;

Fig. 2 shows a block diagram of a one-bit transmitter comprising a second mixer in a closed signal loop, and including a digital interpolator circuit; and

Fig. 3 shows a one-bit transmitter for exponential modulation comprising two interpolator circuits.

Fig. 1 shows a block diagram of a simple exemplary embodiment for a transmitter comprising an arrangement for producing a modulated carrier signal according to the invention, including a sigma-delta (one-bit) signal converter constituted by an adder (1) included in a closed loop, a low-pass filter (2) and a pulse shaper (3) driven with a sample rate 2.fc/n (where fc is the carrier frequency and n a natural number), as well as a (switching) mixer (4) driven with the carrier frequency fc. The arrangement further includes a band-pass filter (5) for frequencies in the band around carrier frequency fc.

A modulation signal (6) is applied to one of the inputs of the adder (1). In the output signal of the pulse shaper (3) the input signal is available as an amplitude modulation on carrier frequencies fc which frequencies are an integer multiple of the sample rate of the pulse shaper (3). The spectrum of the output signal of the mixer (4) is a sum of frequency-shifted spectrums of the output signal of the pulse shaper so that the modulated carrier with frequency fc has a maximum value. In order to avoid that the latter output signal also contains quantization noise modulated in the band around fc, the carrier frequency fc is to be equal to or an integer multiple of the half sample rate of the pulse shaper (3). The output signal of the mixer (4), a one-bit signal, is fed to an output amplifier comprising an (antenna) band-pass filter (5).

Fig. 2 shows a block diagram of a transmitter again comprising an adder (1), a low-pass filter (2), a pulse shaper (3), a (switching) mixer (4) and a band-pass filter (5). Different from that discussed with respect to Fig. 1 the mixer (4) is now included in the closed signal loop and this loop further comprises a second (switching) mixer (7). Distortions and noise within the baseband are strongly suppressed by the first mixer (4) as it is included in the forward-directing part of the closed signal loop. The second mixer (7) in the closed loop provides demodulation of the feedback signal modulated by the first mixer (4). The band-pass filter (5) is a filter for analog signals; the passband may be chosen to be relatively wide when provisions are made that the frequency spectrum alongside the important

frequency bands is relatively clean (shows little quantization noise). Such provisions may be made in a manner known *per se* at the cost of a low sample rate for the pulse shaper (3).

Fig. 2 further shows a digital interpolator circuit (8) operating as a sample rate converter. With this interpolator circuit an input signal (6) which is digital can be converted into a one-bit signal. If, furthermore, not a digital but an analog filter is used as a low-pass filter (2), different sample rates can be used for the interpolator circuit (8) and the pulse shaper (3), which in principle does not pose further restrictions concerning the choice of the carrier frequency fc which is related to the sample rate of the pulse shaper.

Fig. 3 shows a block diagram of a one-bit transmitter for exponential modulation, comprising two interpolator circuits (8, 15 respectively). The transmitter comprises two parallel combinations which include each a closed signal loop with an adder (1, 9, respectively), a low-pass filter (2, 10, respectively), a pulse shaper (3, 11 respectively) and two mixers (4 and 7; 12 and 14 respectively), as well as a combining stage (16) and a band-pass filter (5).

In this transmitter the (digital) baseband signal (6) and its quadrature signal (13) are applied to the interpolator circuits (8, 13 respectively), after which the modulation signals thus converted to one-bit signals are applied to the adders (1, 9 respectively) of the two parallel combinations. The two mixers (4, 7) in one parallel combination are driven by means of a signal whose frequency fc is equal to the signal driving the two mixers (12, 14) in the other parallel combination and whose phase is shifted by 90° relative to that signal. If in the two parallel combinations the pulse shapers are designed in such a way that they generate one-bit signals formed by (mutually equal) positive and (mutually equal) negative pulses having a specific width, separated by blanks of the same width, the two parallel combinations will produce a modulated signal with a carrier frequency fc, while each time the modulated signal from one parallel combination carries information (*i.e.* is not equal to zero) the signal from the other parallel combination is zero, and *vice versa*. These two modulated one-bit signals (with blanks) phase shifted by 90° are combined in the combining stage 16 in a two-level signal which is then fed to the band-pass filter (5). By means of interpolator circuits (8, 15 respectively) digital input signals can be converted into one-bit signals to be applied to the adder (1, 9 respectively) in each one of the two parallel combinations.

Claims

1. Transmitter comprising an electronic arrangement for generating a modulated carrier signal, this arrangement comprising at least an adder included in a closed signal loop, a low-pass filter and a pulse shaper driven with a specific sample rate and constituted by a sigma-delta (one-bit) signal converter, characterized in that this arrangement comprises a mixer driven with carrier frequency fc, so that the output signal of the pulse shaper is applied to the mixer and the frequency fc is equal to that or an integer multiple of the half sample rate.

2. Arrangement as claimed in Claim 1, characterized in that the mixer forms part of a closed signal loop and this loop comprises a second mixer driven with carrier frequency fc, so that the output signal of the first mixer is applied to the second mixer.

3. Arrangement as claimed in Claim 2, characterized in that the closed signal loop comprises a power amplifier.

4. Arrangement as claimed in one of the Claims 1, 2 or 3, characterized in that the arrangement comprises a digital-to-analog signal converter or a sample rate converter whose output is connected to an input of the adder.

5. Transmitter comprising an electronic arrangement for generating an exponentially modulated carrier signal, which transmitter comprises at least two parallel combinations for modulating a carrier signal, or a signal shifted in phase by 90° relative to this carrier signal respectively, by means of an in-phase baseband signal or a quadrature baseband signal respectively, characterized in that the parallel combinations are constituted each by an arrangement as claimed in Claim 2, wherein the two mixers in one parallel combination are driven by means of a signal whose frequency fc is equal to the signal by means of which the two mixers in the other parallel combination are driven and is phase-shifted by 90° relative to that signal.

6. Transmitter as claimed in Claim 5, characterized in that the transmitter comprises two digital-to-analog signal converters or two sample rate converters, the output of one or the other digital-to-analog signal converter or the sample rate converter respectively, being connected to an input of the adder in one or the other parallel combination.

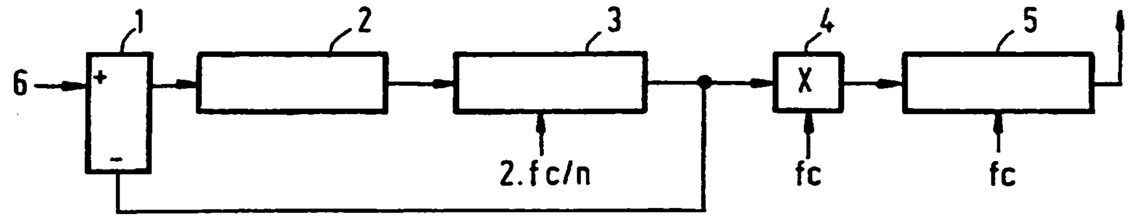

FIG.1

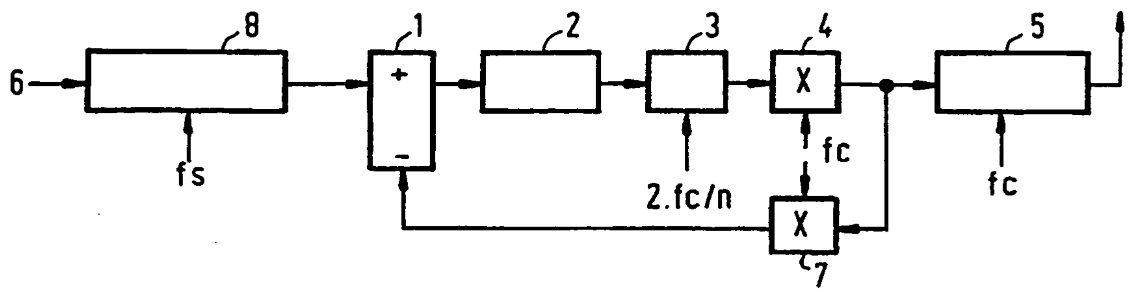

FIG.2

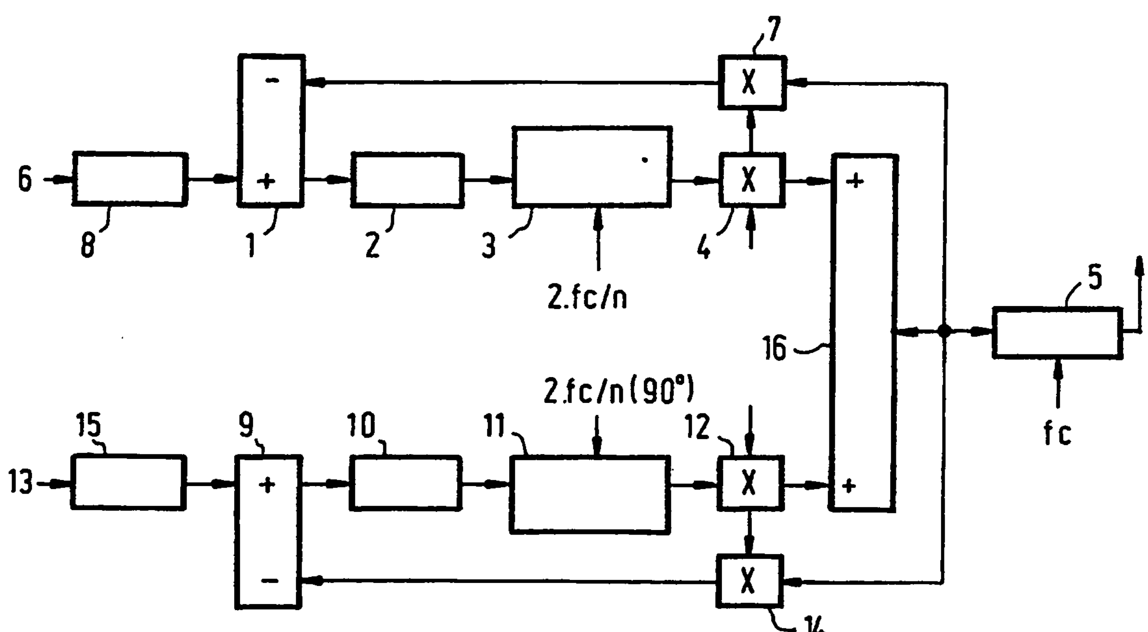

FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 20 1429

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	IEEE TRANSACTIONS ON COMMUNICATIONS vol. COM28, no. 8, August 1975, NEW YORK, US pages 793 - 798; D. C. COX: 'Linear amplification by sampling techniques: a new application for delta coders ' * figure 4 *	1-6	H 04 B 14/06 H 04 L 27/06 H 04 L 27/04 H 04 L 27/20
A	NEUES AUS DER TECHNIK no. 3, June 14, 1983, WURZBURG, DE page 3; 'Delta - Sigma - Modulator ' * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 04 L H 04 B H 03 M

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	13 September 91	SCRIVEN P.

CATEGORY OF CITED DOCUMENTS

- X: particularly relevant if taken alone
- Y: particularly relevant if combined with another document of the same catagory
- A: technological background
- O: non-written disclosure
- P: intermediate document
- T: theory or principle underlying the invention
- E: earlier patent document, but published on, or after the filing date
- D: document cited in the application
- L: document cited for other reasons
- &: member of the same patent family, corresponding document